CHARCOAL WOUND DRESSINGS

The present invention relates to charcoal based wound dressings, in particular for use as odor-absorbent wound dressings.

GB-A-1301101 describes an activated carbon cloth for use as an odor absorbent wound dressing, for example in the treatment of heavily infected wounds, varicose ulcers and fungating carcinomas. The cloth is produced by carbonising a cellulosic cloth, such as a suitably treated woven viscose rayon cloth. The activated carbon cloth is relatively friable, and tends to shed particles of carbon in use. For this reason it is preferably enclosed or covered by a suitable protective, permeable cover, such as a spunbonded nylon nonwoven or a gauze to prevent particles of carbon from escaping into the wound in use.

EP-A-0053936 describes activated carbon products for use in odor-absorbent wound dressings, wherein the carbon has been further treated with an antimicrobial substance, such as iodine. The activated carbon may be in the form of an activated carbon cloth in a porous envelope, such as a spunbonded nylon fabric envelope, as described above. In other embodiments, the carbon may be in the form of activated carbon powder dispersed in a foamed elastomer matrix.

GB-A-2127389 describes an activated charcoal cloth or felt that has been produced so that it contains elemental silver dispersed therein as a bacteriostatic. Again, the cloth is preferably enclosed or covered by a suitable protective, permeable cover, such as a spunbonded nylon scrim or a gauze to prevent particles of carbon from escaping into the wound in use. Products of this type have been commercially available for a number of years under the Registered Trade Mark ACTISORB from Johnson & Johnson Medical Limited of Gargrave, Yorkshire, UK.

WO86/05970 describes an antibacterial wound dressing comprising four layers which are, in order: (1) a first layer of a permeable material; (2) a layer of a semi-permeable, adhesive material; (3) a charcoal cloth or felt; and (4) a non-adherent

wound-contacting layer of a permeable material; wherein layers (1), (2) and (4) together form an envelope for the charcoal cloth to prevent escape of carbon particles into the wound.

It is also known to use activated charcoal in particulate form as an adsorbent in blood purification to absorb various toxic materials. However, particle release and platelet adhesion have prevented widespread clinical use of activated charcoal for blood purification. Various polymeric coatings for microencapsulation of the activated charcoal have been suggested to improve their blood compatibility. The state of the art is reviewed by T. Chandy and C.P. Sharma in *Journal of Biomaterials Applications* Vol. 13 (October 1998) pages 128-157.

It has now been found that charcoal cloth wherein the particles or fibers of charcoal have been coated directly with a water-insoluble polymer can exhibit less tendency to shed carbon particles, greater structural integrity, and other benefits, while maintaining odor absorbent properties.

The present invention provides a wound dressing material comprising a charcoal cloth wherein the charcoal is coated with a substantially water-insoluble polymer.

The charcoal cloth may be any suitable charcoal cloth formed by carbonizing an organic fabric. The charcoal cloth may include antimicrobial agents, such as iodine or silver. Suitable charcoal cloths are described in GB-A-1301101, EP-A-0053936 and GB-A-2127389, the entire contents of which are incorporated herein by reference.

The substantially water-insoluble polymer will normally be a hydrophilic polymer so as not to diminish the liquid absorbency of the charcoal cloth. The term "water-insoluble" indicates that the polymer has low solubility in water, typically less than about 10g/liter, for example less than about 1g/liter, at physiological temperatures (30°C) and pH7. The polymer may for example be a synthetic polymer such as a nylon, or a semi-synthetic polymer such as an insoluble cellulose derivative (e.g. collodion or cellulose acetate) or an insoluble starch derivative, or it may be a

polymer of natural origin such as chitosan, an insoluble alginate, albumin, guar gum, pectins, gelatins, hyaluronates, gelatins, hyaluronates, hemicellulose, chitin, agar, xanthan, starch, amylose, amylopectin, alternan, gellan, mutan, dextran, pullulan, fructan, locust bean gum, carrageenan, glycogen, glycosaminoglycans and collagen and derivatives and mixtures thereof. The latter polymers of natural or semi-synthetic origin are especially suitable as they can present a wound friendly, non-allergenic and humectant surface to the wound being treated. Certain of these insoluble polymers may undergo gradual degradation and resorption in vivo. Especially suitable are polymers that can be coated onto the charcoal cloth in a soluble form an aqueous solution and then be rendered insoluble in situ by suitable treatment, for example cross-linking. Such polymers include chitosan, pectins, gelatins, alginates and guar gum.

An especially suitable coating polymer is chitosan. Chitosan is prepared from chitin, which is a natural biopolymer extracted from the outer shell of shrimps and crabs. Chitin is composed of N-acetyl-D-glucosamine units. The chitin is partially deacetylated, for example by treatment with 5M-15M NaOH, to produce chitosan. Complete deacetylation of the chitin is not a practical possibility, but preferably the chitosan is at least 50% deacetylated, more preferably at least 75% deacetylated. Chitosan has been employed for wound treatment in various physical forms, e.g. as a solution/gel; film/membrane; sponge; powder or fiber. Chitosan in the free base form is swellable but not substantially soluble in water at near-neutral pH, but soluble in acids due to the presence of ammonium groups on the chitosan chain. Typically, the average molecular weight of the chitosan as determined by gel permeation chromatography is from about 10^5 to about 10^6.

Another suitable group of polymers is the alginates. Sodium alginate can be applied to the charcoal cloth as an aqueous solution. It can then be rendered insoluble in situ by crosslinking with multivalent cations, such as by treatment with an aqueous calcium salt. Pectin can be applied in the same way. Other polymers, such as hyaluronate salts or gelatins, can be applied to the charcoal cloth in solution and then rendered insoluble in situ by treatment with covalent cross-linking agents such as glutaraldehyde or dicyclohexyl carbodiimide.

The polymer layer may further comprise one or more therapeutic agents. The one or more therapeutic agents may be any substance suitable for the treatment of wounds, but does not include the polymer used to form the coating, which may independently promote wound healing. In certain embodiments the therapeutic agents are selected from the group consisting of antiseptics, antibiotics, analgesics, steroids and growth factors. Preferred therapeutic agents are the antimicrobials, in particular antibiotics and antiseptics such as colloidal silver, silver sulfadiazine, povidone iodine, chlorhexidine, and mixtures thereof. Preferably, the polymeric coating material according to the present invention comprises from about 0.01% to about 20% by weight of the one or more therapeutic substances, more preferably from about 1% to about 5% by weight.

The polymer material may further comprise one or more medically acceptable plasticisers and/or humectants known in the art. The one or more plasticisers, when present, may suitably comprise any of the following either alone or in combination: at least one polyhydric alcohol (such as glycerol, polyethylene glycol, or sorbitol), at least one ester derived therefrom, at least one polymeric alcohol (such as polyethylene oxide) and/or at least one mono- or poly-alkylated derivative of a polyhydric or polymeric alcohol (such as alkylated polyethylene glycol). Glycerol is the preferred plasticiser. When present, the organic plasticiser may typically comprise up to about 50% by weight of the polymer composition.

The charcoal cloth is coated with the polymer. The polymer is not present as a separate layer of material, but is distributed through the body of the charcoal cloth to bind and coat the charcoal particles and fibers. In certain embodiments, the polymer is present as as a thin film covering and binding the individual fibers and particles of the charcoal cloth. The film is sufficiently thin not to interfere significantly with the liquid absorbency and odor absorbency of the charcoal cloth. The mean thickness of the film is typically about 0.01 to about 10 μm, for example about 0.1 to about 4μm.

In other embodiments, the polymer material may be a porous (sponge-like) polymer coating or matrix, formed by freeze-drying a dispersion of polymer impregnated into the charcoal cloth as described in more detail below. The porous coating is still effective to bind the charcoal cloth, and also provides the necessary porosity for liquid and odor absorbency.

Suitably, the dry weight ratio of the water insoluble polymer to the charcoal is from about 0.01 to about 2, for example from about 0.1 to about 1. The polymer may be substantially uniformly distributed through the thickness of the charcoal cloth, or in some embodiments there may be a gradient of polymer concentration through the thickness of the cloth.

Suitably, the wound dressing material according to the invention has a water absorbency of at least about 0.5g/g, for example at least about 1g/g, and in some cases at least about 2g/g, or even at least about 5g/g. The absorbency is measured on uncompressed fabric after immersion in phosphate buffered saline at 30°C and pH7 for 15 minutes followed by removing the sample with tweezers and draining under gravity without compression.

In a second aspect, the present invention provides a wound dressing comprising a wound dressing material according to the invention.

The wound dressing may consist of, or consist essentially of, the coated charcoal cloth, since the polymer coating on the charcoal cloth can render it wound friendly and reduce the tendency to shed carbon particles into the wound to an acceptable level. For the same reason, the charcoal cloth material according the the present invention may form a wound contacting layer of a multilayer wound dressing.

In other embodiments, the dressing may comprise a porous or microporous wound facing sheet covering the charcoal cloth of the invention. The wound facing sheet can provide advantages of lowered adherency and control over the levels of moisture in the wound. The wound facing sheet is normally permeable to gases

and liquids, in order to allow wound exudates to pass into the charcoal cloth layer.

In certain embodiments, the charcoal cloth is enclosed in an envelope comprising porous or microporous sheet materials. In typical embodiments, the envelope comprises a nonwoven fabric, for example a spunbonded nylon fabric of the kind currently used to make ACTISORB. Preferably, the material of the envelope includes a fusible component so that the edges can be bonded together by the application of heat and pressure. For example, the fabric may be a nonwoven fabric containing both fusible (such as polypropylene) and non-fusible (such as cellulose) fibers. Suitable envelopes are described in GB-A-1301101, EP-A-0053936, GB-A-2127389 and WO86/05970, the entire contents of which are incorporated herein by reference.

It will be appreciated that any one or more of the other layers known for use in wound dressings may be present in the wound dressings according to the present invention. Suitable layers include any one or more selected from the group consisting of wound contacting layers, hydrogel layers, hydrocolloid layers, liquid absorbent layers, perforated liquid transmission layers, adhesive layers, semipermeable backing layers, and protective cover sheets for removal before application of the dressing.

The wound dressing according to the invention may be sterile and packaged in a microorganism-impermeable container.

In a further aspect, the present invention provides a method of making a wound dressing material comprising the steps of impregnating a charcoal cloth with a dispersion of a polymer or polymer precursor in a solvent, followed by drying the charcoal cloth to leave a coating of the polymer or polymer precursor on the charcoal.

The solvent may be aqueous or non-aqueous. In a number of embodiments, the polymer or polymer precursor is first applied to the charcoal cloth in an aqueous

solution, and the process further comprising a step of treating the polymer to render the polymer or polymer precursor insoluble in water. For example, the polymer may be applied as a solution of a monovalent salt that is then treated with a multivalent cation such as calcium chloride (in aqueous or alcoholic solution) to generate an insoluble salt of the polymer with the multivalent cation. This method is especially suitable for alginates and pectins. The polymer may be applied in acid or alkaline solution, which is then neutralized to render it insoluble. This method is especially suitable for chitosan, which is soluble in acids but not at neutral or alkaline pH. The polymer may be covalently cross-linked in situ, for example by treatment with dicyclohexyl carbodiimide, glutaraldehyde or epichlorhydrin to render it insoluble. This method is especially suitable for gelatin and hyaluronic acid, but may also be applied to other polymers such as chitosan in addition to, or instead of, the other methods discussed above. In other embodiments, the cross-linking agent may be a polyanionic cross-linking agent, such as borate anions for cross-linking guar gum. In yet other embodiments, the cross-linking agent may be a solution of a second polymer that forms an insoluble complex with the first polymer, for example the charcoal cloth may be treated sequentially with solutions of a xanthan gum and a galactomannan gum to precipitate a xanthan/galactomannan insoluble material.

The step of drying may be carried out at substantially atmospheric pressure, in which case the polymer is likely to form a thin film on the charcoal substrate. In other embodiments, the step of drying (which may be carried out either before or after the step of cross-linking) may be carried out by freeze-drying or solvent drying. These methods result in a more porous coating of the polymer on the charcoal. Suitable methods of freeze drying and solvent drying are described for example in EP-A-1153622 and EP-B- 0838491 respectively, the entire contents of which are incorporated herein by reference.

The method according to the present invention is suitable for the preparation of wound dressing materials according to the present invention as hereinbefore described. It will be appreciated that any feature that is described in connection

with any one aspect of the invention is also suitable for application in connection with any other aspect.

Specific embodiments of the invention will now be described further, by way of example, as follows.

Example 1

A sample of silver-containing charcoal cloth prepared substantially as described in GB-A-2127389 was obtained from a commercially available ACTISORB wound dressing supplied by Johnson & Johnson Medical Limited of Gargrave, UK.

The charcoal cloth was dipped in a solution of chitosan 0.5% (w/v) in 2% acetic acid, removed, and air dried at 37°C. The treated cloth was then dipped in a 1%w/v solution of NaOH in methanol to render the chitosan insoluble in water. The coated charcoal cloth was then washed thouroughly with hot water followed by cold water. The final weight ratio of chitosan to charcoal cloth was about 0.2:1.

The resulting cloth had appearance, liquid absorbency and odor absorbency similar to the untreated charcoal cloth, but tended to shed fewer particles.

The above example has been described for the purpose of illustration only. Many other embodiments falling within the scope of the accompanying claims will be apparent to the skilled reader.